



# Multinomial Processing Tree (MPT) Modeling: MPT Modeling with multiTree

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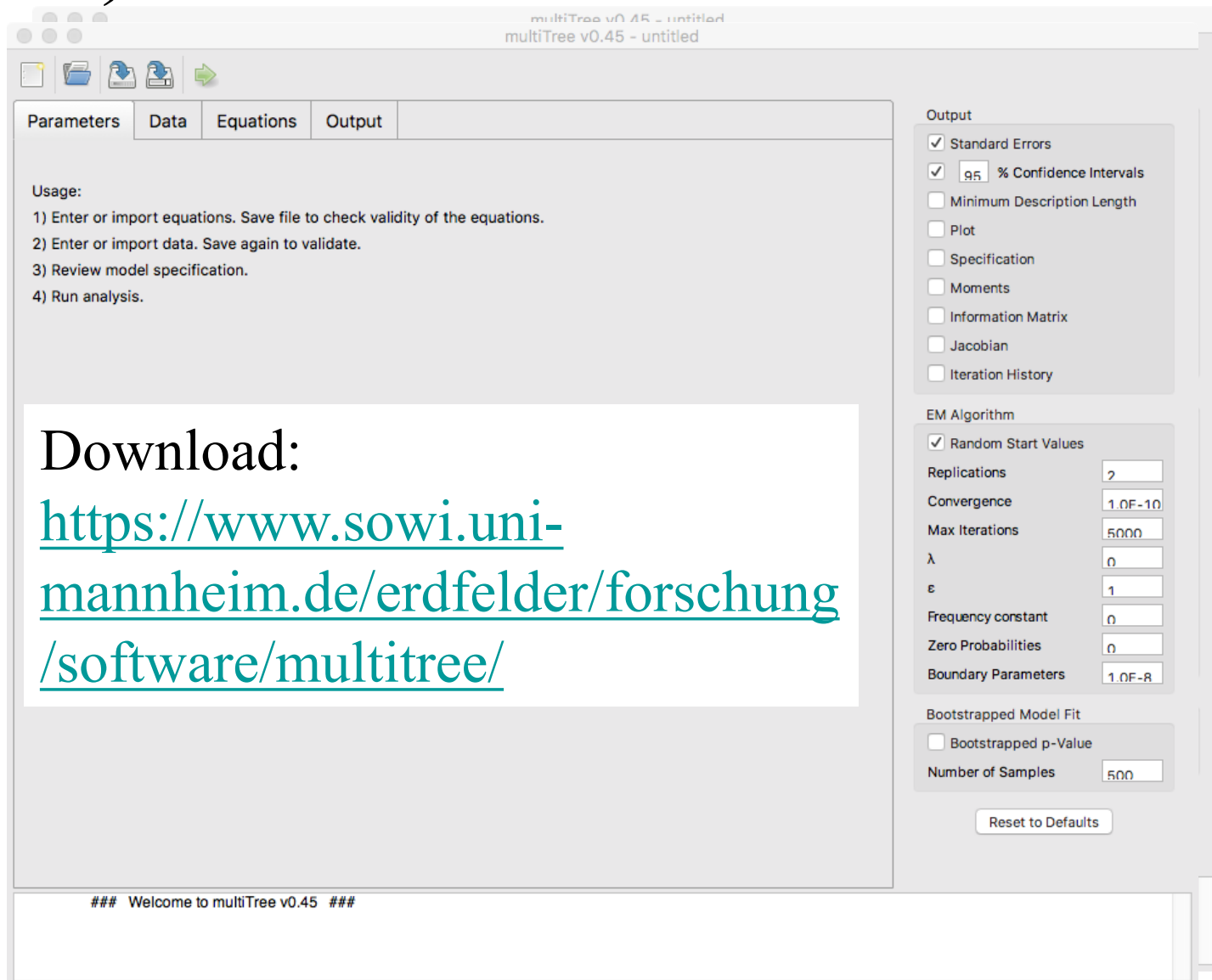
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(slides adapted from Edgar Erdfelder)

## 2) Applications

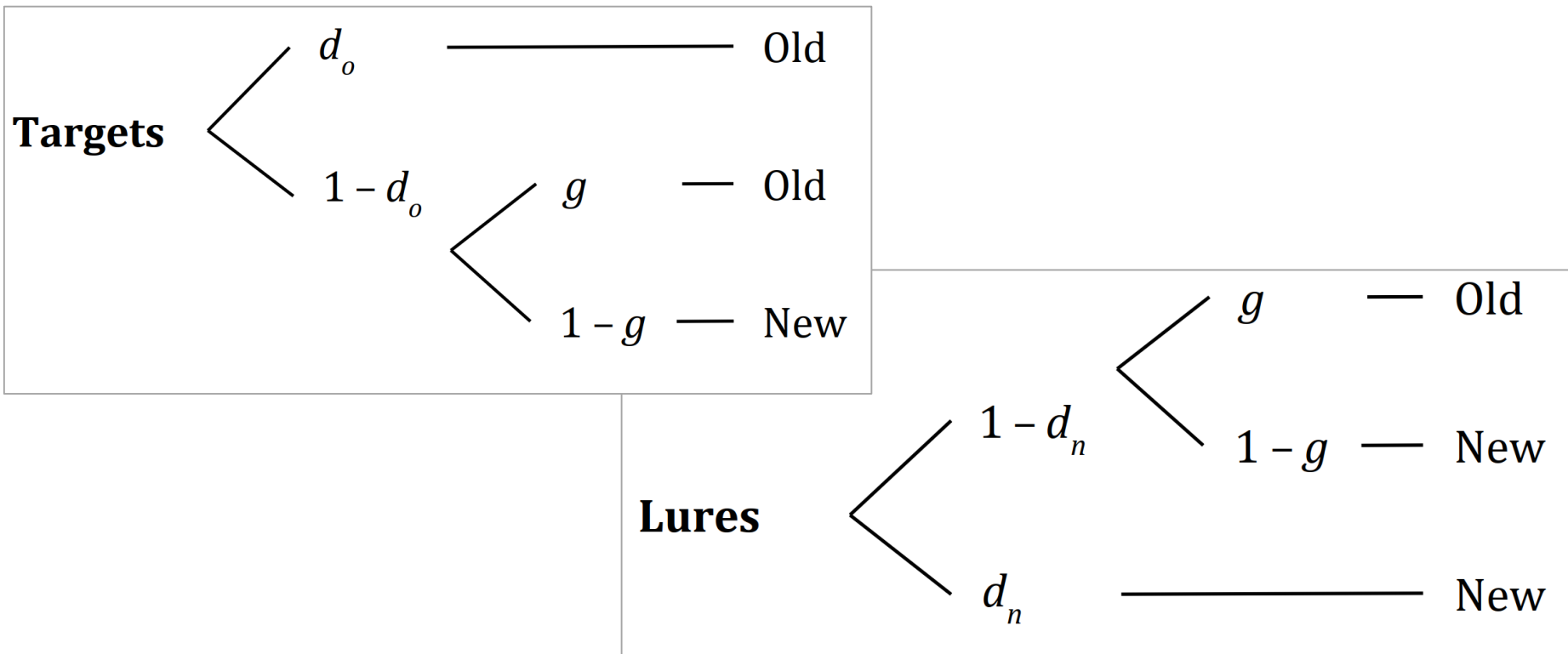
- 2.1) Model definition
- 2.2) Identifiability checks
- 2.3) Practical exercises

## 2) Introduction to multiTree



## 2.1) Application: Define Model

1.) Open multiTree and provide the model equations of the Two-High-Threshold Model:



# Two-High-Threshold Model (2HTM)

The screenshot displays the multiTree v0.46 software interface for the file 'two-high-threshold-model.mpt'. The main window is divided into several sections:

- Menu Bar:** File, Model, Analysis, Help
- Toolbar:** Icons for file operations (new, open, save, save as) and a run button.
- Tabbed Interface:** Parameters, Data, Equations, Output, Model Builder. The 'Equations' tab is currently selected.
- Equations Tab:** Contains a table of model equations with variables and their corresponding formulas.
- Output Panel:** A list of checkboxes for output options, including Standard Errors, 95% Confidence Intervals, Minimum Description Length, Plot, Specification, Moments, Information Matrix, Jacobian, and Iteration History. The '95' value is entered in a text box next to the '95 % Confidence Intervals' checkbox.
- EM Algorithm Panel:** A section for the EM algorithm with a checked 'Random Start Values' option.

Variable	Old Value	New Value	Equation
Target	T_old	do	
Target	T_old	$(1 - do) * g$	
Target	T_new	$(1 - do) * (1 - g)$	
Lure	L_new	dn	
Lure	L_old	$(1 - dn) * g$	
Lure	L_new	$(1 - dn) * (1 - g)$	

# Application: Provide Data

2.) Provide the following observed frequencies:

	„old“	„new“
Target	65	35
Lure	13	87

# Data

The screenshot shows the multiTree v0.46 software interface. The title bar reads "multiTree v0.46 - two-high-threshold-model.mpt". The menu bar includes "File", "Model", "Analysis", and "Help". The toolbar contains icons for opening files, saving, and running. The "Data" tab is selected, showing a list of variables: "Title: Example for MPT workshop", "T\_old: 65", "T\_new: 35", "L\_old: 13", and "L\_new: 87". The "Data Type" is set to "Category Frequencies". The "Output" panel on the right shows options for "Standard Errors", "95 % Confidence Intervals", "Minimum Description Length", "Plot", "Specification", "Moments", "Information Matrix", "Jacobian", and "Iteration History".

multiTree v0.46 - two-high-threshold-model.mpt

File Model Analysis Help

Parameters Data Equations Output Model Builder

Data Type Category Frequencies Analyze Batch Anal

Title: Example for MPT workshop  
T\_old 65  
T\_new 35  
L\_old 13  
L\_new 87

Output

- ☒ Standard Errors
- ☒ 95 % Confidence Intervals
- ☐ Minimum Description Length
- ☐ Plot
- ☐ Specification
- ☐ Moments
- ☐ Information Matrix
- ☐ Jacobian
- ☐ Iteration History

# Application: Model Definition

## 3.) Is the model identifiable?

multiTree v0.46 - two-high-threshold-model.mpt

File Model Analysis Help

Parameters Data Equations Output Model Builder

Hierarchical Model Families

☐ Define current model as new baseline model (needs to be estimated before it can serve as a baseline)

☐ Compare current model against baseline model

dn free 0.5

do free 0.5

g free 0.5

Specification

Number of trees	2
Number of categories	4
Number of free categories	2
Number of parameters	3
Number of constrained parameters	0
Degrees of freedom	-1

Output

☒ Standard Errors

☒ 95 % Confidence Intervals

☐ Minimum Description Length

☐ Plot

☐ Specification

☐ Moments

☐ Information Matrix

☐ Jacobian

☐ Iteration History

EM Algorithm

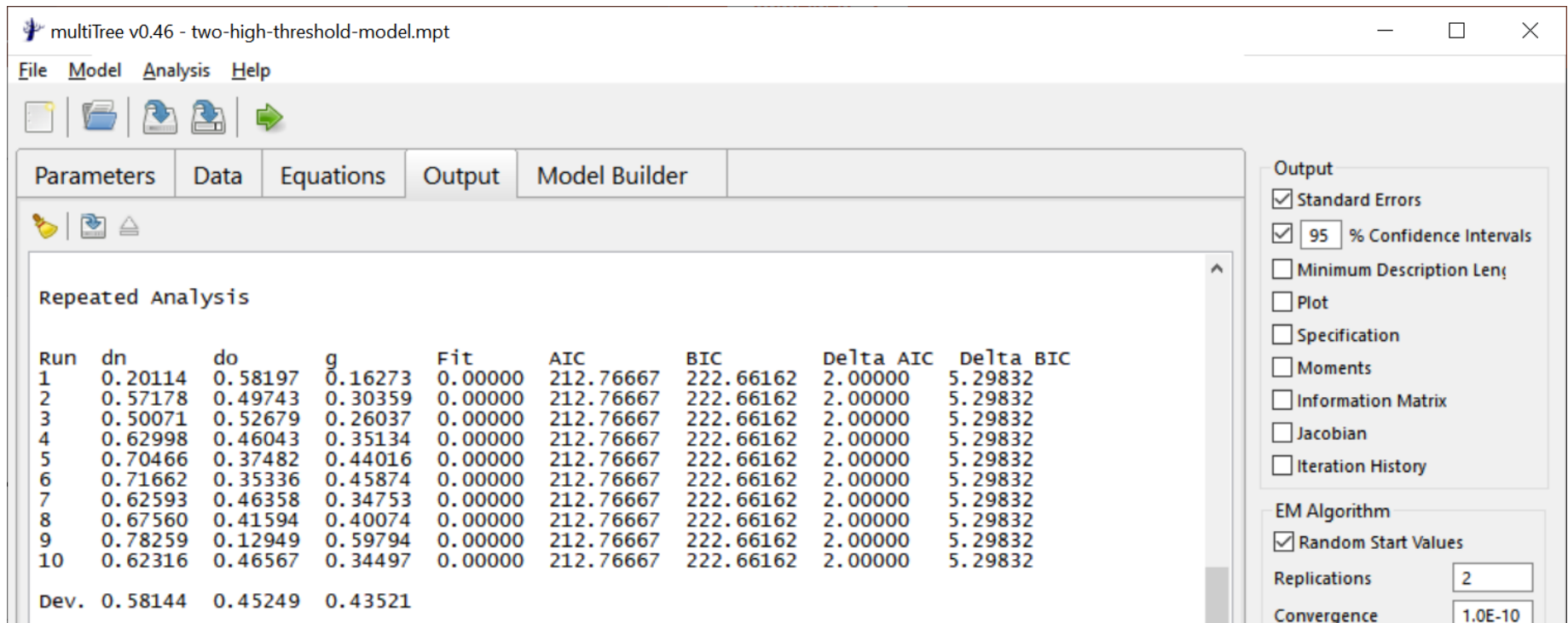
☒ Random Start Values

Replications 2



## 2.2) Application: Identifiability

### 4.) Check identifiability via repeated analysis



The screenshot displays the multiTree v0.46 software interface. The 'Output' tab is selected, showing the results of a 'Repeated Analysis'. The results are presented in a table with columns for Run, dn, do, g, Fit, AIC, BIC, Delta AIC, and Delta BIC. The table shows 10 runs, all with identical results, indicating perfect identifiability. The 'Output' panel on the right shows various options checked, including 'Standard Errors', '95 % Confidence Intervals', and 'Random Start Values'.

Run	dn	do	g	Fit	AIC	BIC	Delta AIC	Delta BIC
1	0.20114	0.58197	0.16273	0.00000	212.76667	222.66162	2.00000	5.29832
2	0.57178	0.49743	0.30359	0.00000	212.76667	222.66162	2.00000	5.29832
3	0.50071	0.52679	0.26037	0.00000	212.76667	222.66162	2.00000	5.29832
4	0.62998	0.46043	0.35134	0.00000	212.76667	222.66162	2.00000	5.29832
5	0.70466	0.37482	0.44016	0.00000	212.76667	222.66162	2.00000	5.29832
6	0.71662	0.35336	0.45874	0.00000	212.76667	222.66162	2.00000	5.29832
7	0.62593	0.46358	0.34753	0.00000	212.76667	222.66162	2.00000	5.29832
8	0.67560	0.41594	0.40074	0.00000	212.76667	222.66162	2.00000	5.29832
9	0.78259	0.12949	0.59794	0.00000	212.76667	222.66162	2.00000	5.29832
10	0.62316	0.46567	0.34497	0.00000	212.76667	222.66162	2.00000	5.29832
Dev.	0.58144	0.45249	0.43521					

Output panel options:

- ☒ Standard Errors
- ☒ 95 % Confidence Intervals
- ☐ Minimum Description Length
- ☐ Plot
- ☐ Specification
- ☐ Moments
- ☐ Information Matrix
- ☐ Jacobian
- ☐ Iteration History

EM Algorithm panel options:

- ☒ Random Start Values
- Replications: 2
- Convergence: 1.0E-10

## 2.2) Application: Identifiability

### 5.) Obtaining an identifiable model:

ParametersDataEquationsOutputModel Builder

Hierarchical Model Families

☐ Define current model as new baseline model (needs to be estimated before it can serve as a baseline).

☐ Compare current model against baseline model

dnfree0.52

do= dn0.52

gfree0.27083

Repeated Analysis

Run	dn	do	g	Fit
1	0.52000	0.52000	0.27083	0.00000
2	0.52000	0.52000	0.27083	0.00000
3	0.52000	0.52000	0.27083	0.00000
4	0.52000	0.52000	0.27083	0.00000
5	0.52000	0.52000	0.27083	0.00000
6	0.52000	0.52000	0.27083	0.00000
7	0.52000	0.52000	0.27083	0.00000
8	0.52000	0.52000	0.27083	0.00000
9	0.52000	0.52000	0.27083	0.00000
10	0.52000	0.52000	0.27083	0.00000
Dev.	0.00000	0.00000	0.00000	

Specification

Number of trees	2
Number of categories	4
Number of free categories	2
Number of parameters	3
Number of constrained parameters	1
Degrees of freedom	0

## 2.2) Identifiability Checks in multiTree

- Repeated analysis
  - Check stability of parameters estimates for a specific vector of observed frequencies
- Simulated identifiability
  - Check recovery of simulated parameters:
  - Repeated data generation for random parameter vectors  $\theta$  in  $\Omega$  followed by estimation
- Get Jacobian
  - a) Check rank of the Jacobian for a random parameter  $\theta$
  - b) Use specific parameter values  $\theta$  from parameter tab

# Model Fitting: Output

The screenshot shows the multiTree v0.46 software interface. The title bar reads "multiTree v0.46 - two-high-threshold-model.mpt". The menu bar includes "File", "Model", "Analysis", and "Help". Below the menu bar is a toolbar with icons for file operations and a green arrow. The main window has tabs for "Parameters", "Data", "Equations", "Output", and "Model Builder". The "Output" tab is selected, displaying the following text:

File: D:\R\Treebugs\_Project\MPT-workshop\2020-02 MPI (Berlin) ^  
Data Set 1: Title: Example for MPT workshop

Estimation proceeded normally.

Model Fit

PD $\lambda$ lambda=0.0 (df=0) = 0.00000

ln(likelihood) = -103.38334  
AIC = 210.76667  
BIC = 217.36330  
Delta AIC = 0.00000  
Delta BIC = 0.00000

Parameter Estimates, Standard Errors, and Confidence Intervals

dn	= 0.52000	(0.05836)	[0.40561 - 0.63439]
do	= dn		
g	= 0.27083	(0.05774)	[0.15766 - 0.38401]

On the right side, there are two panels. The "Output" panel has checkboxes for "Standard Errors" (checked), "95 % Confidence Intervals" (checked), "Minimum Description Length" (unchecked), "Plot" (unchecked), "Specification" (unchecked), "Moments" (unchecked), "Information Matrix" (unchecked), "Jacobian" (unchecked), and "Iteration History" (unchecked). The "EM Algorithm" panel has a checked "Random Start Values" checkbox and input fields for "Replications" (2), "Convergence" (1.0E-10), "Max Iterations" (5000), " $\lambda$ " (0), " $\epsilon$ " (1), "Frequency constant" (0), "Zero Probabilities" (0), and "Boundary Parameters" (1.0E-8).

## 2.3) Practical Exercises

1. Extend the 2HTM to two base rate conditions:

		„old“	„new“
30% Targets	Target	65	35
	Lure	13	87
70% Targets	Target	83	17
	Lure	43	57

2. Estimate the model for both conditions jointly.
3. Does  $g$  differ significantly between conditions?